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REPORT NO. H-1022

DATE 1 February 1934

SUBJECT

PHOTOGRAPHY WITH INFRA-RED PLATES



BY

NAVAL RESEARCH LABORATORY
BELLEVUE, D. C.

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Report No.
H-1022
Photography with Infra-red plates.

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NAVY DEPARTMENT
BUREAU OF ENGINEERING

REPORT ON

Photography with Infra-Red Plates.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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A B S T R A C T

Photographs, in daylight from the roof of the Laboratory, of the Potomac River scene through haze and fog with infra-red sensitive plates showed that objects could just be seen in the pictures at about 1.2, 4 and 8 miles when the haze and fog were such that the objects could be seen with the eye at about 1, 3 and 6 miles, respectively. Twenty-two of the photographs are reproduced.

INTRODUCTION

It has been known for a long time that pictures taken with infra-red sensitive photographic plates bring out the contrasts of a scene differently from pictures taken with ordinary plates (1). With the infra-red plate the veiling effect of haze can often be eliminated to a considerable extent (2), (3). The earlier plates were relatively insensitive and long exposures were required. Within recent years the sensitiveness of the plates has been increased until it is comparable with the sensitiveness of ordinary panchromatic plates or film. The infra-red plates are available commercially and have been used in photography from the air. In England pictures taken with infra-red plates are commonplace and are seen on calendars, etc.

The experiments described in the following paragraphs were carried out to find the answer to the question, "How far can one photograph objects through haze and fog by means of infra-red plates as compared to the distance at which the objects can be seen through the haze and fog?" The answer is given in Table 1 and the curves of Plate 13.

EXPERIMENTAL DETAILS

Three types of photographic plates were used: commercial panchromatic, infra-red plates Type R, and infra-red plates Type Q. We shall refer to these as P, R and Q plates, respectively. The P plates were used with a yellow filter Wratten A over the lens of the camera to yield a response-to-light curve similar to that of the eye. Pictures taken in this way with the P plates were fairly faithful reproductions of the scene as the eye saw it, the visibility of objects derived from the plates being the same as the eye visibility. With the R and Q plates a red filter Wratten K₂ was used. The R plates (4) were sensitive to the wave-length region from about 0.76 to 0.84 μ . It will be recalled that the red sensitivity of the eye falls to a low value or zero beyond about 0.72 μ . The Q plates were mainly sensitive to the region from 0.88 to 1.02 μ , although their sensitivity curve extended, in decreasing grade, from 0.88 μ to shorter wave-lengths as far as 0.80 μ . The R plates are about the same with respect to keeping quality as panchromatic plates. The Q plates, however, must be kept on ice, and even so deteriorate after several months. With

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- (1) R.W. Wood, "Physical Optics", Chapter 22, 1911.
 - (2) "Aerial Haze and its Effect on Photography from the Air", Eastman Kodak Company, 1923.
 - (3) Rawling, "Infra-red Photography", 1933.
 - (4) C.E.K. Mees, Journal of the Optical Society of America, 21, 753, 1931; 22, 204, 1932; 23, 229, 1933.
-

lenses which we used, one of 27 inches and one of 8 inches focal length, the position of focus for each lens was the same for the P, R and Q plates.

The relative sensitivities of the P, R and Q plates were as 1:1/30;1/300, or the times of exposure as 1:30:300. If the R and Q plates were sensitized with ammonia the relative times of exposure became about 1:15:50.

In general, water and sky appeared darker and green grass and leaver whiter on the R and Q plates than on the P plates, although the degree of the changes varied with the amount and direction of the illumination. Shadows were darker on the infra-red plates than on the P plates, and therefore, because of the heightened contrast, details of an object may appear more clearly on the infra-red plates although the object itself may have no unusual spectral characteristics in the infra-red.

EXPERIMENTAL RESULTS

Nineteen sets of pictures were taken from the roof of the Laboratory on clear, hazy and foggy days, each set consisting of either P and R, or P and Q, or P, R and Q plates. At the time that a set was taken, careful note was made of the "eye visibility" that is, the distance in nautical miles of the most distant object which could be seen. Two scenes were used, one up the Potomac River to the north and one down the Potomac River to the south. From each plate the "plate visibility", i.e. the distance to the most distant object which could be seen on the plate, was determined.

The results are given in Table 1. Ten of the sets are reproduced in Plates 3 to 12, as indicated in Table 1. Plates 1 and 2 give the distances to various objects in the two scenes. The P and Q plates were not sensitized with ammonia and the lens was stopped to a small aperture, so that rather long exposure times were necessary; they could, of course, be greatly reduced. The exposure times were from 1/5 to 1 second for the P plates, 4 to 20 seconds for the R plates and 3 to 8 minutes for the Q plates. In many of the Plates 3 to 12 the water of the R and Q pictures appears smoother than of the P pictures merely because of the longer exposure. In picture R of Plate 9 the blurred white spot on the water was a sail boat coming down the river.

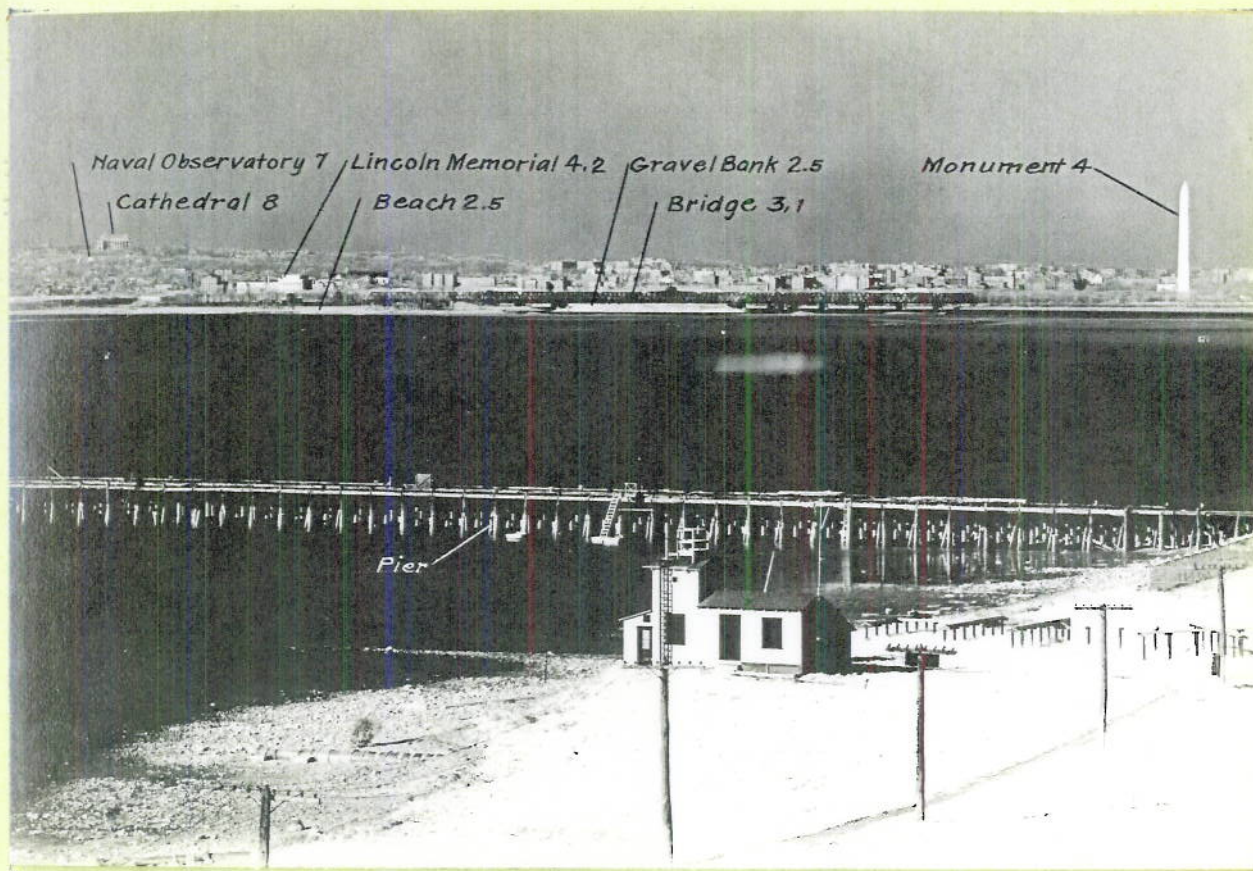
The plate visibilities in nautical miles of Table 1 are plotted as ordinates in the curves of Plate 13 against the eye visibilities as abscissas. Since the P plate and the eye yield the same visibility the curve for this plate is a straight line at 45° to the X-axis. The curves stop at 8 miles because that was the distance to the most remote object available in the present experiments. From Plate 13 it follows that the increase in penetration through haze of the infra-red plates compared to the eye increases as the haze gets thinner. We may add another point to the R curve by mentioning that Stevens photographed Mt. Shasta from an airplane with R plates at a distance of 330 miles when he could only see about 150 miles (3).

The results support the conclusion that photography with infra-red plates can not be regarded as a means of penetrating fog to any useful extent. The appreciable penetration of thin haze which the plates afford may possibly be of Naval interest. Quite apart from haze penetration, however, it would be of interest to know what sea scenes photographed with infra-red plates would look like, for example, scenes of ships at a distance, of shell splashes, of guns firing, etc. In such experiments one would preferably use the R plates and disregard for the present the Q plates. The extension in the infra-red which the Q plates offer would appear to offer but slight advantage over the R plates in contrast effects of sea-scapes.

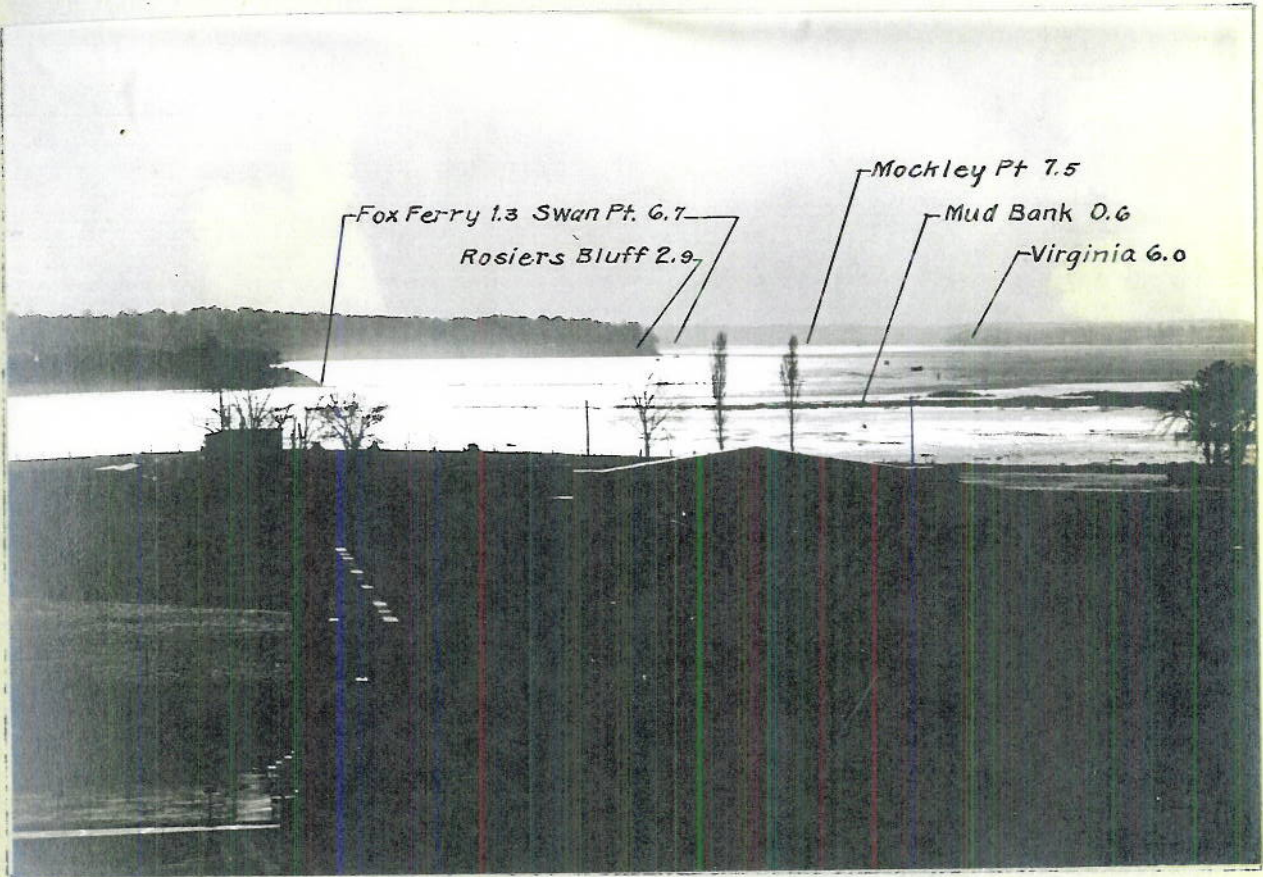
TABLE 1

EYE AND PLATE VISIBILITIES

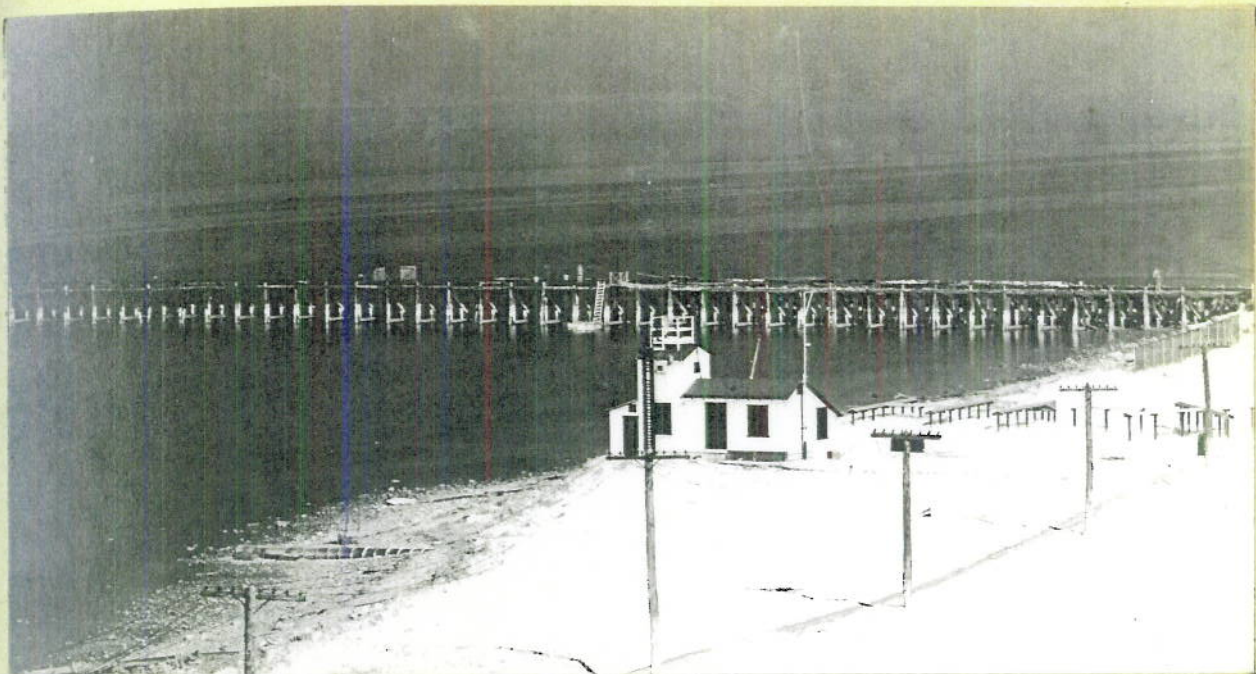
<u>Set</u>	<u>Plate</u>	<u>Eye or</u> <u>P</u>	<u>R</u>	<u>C</u>
1	3	2 miles	2.5 miles	-- miles
2	4	2	2	--
3	5	4	5.5	--
4	6	5	6	--
5	7	6	8	--
6	8	7	8+	--
7	9	greater than 12		
8	10	greater than 12		
9		1	1	1.5
10		1.5	1.5	--
11		2.2	2.5	3
12	11	3	3	3.5
13		5	--	8
14		8	--	8+
15		8	--	8+
16		greater than 8		
17		greater than 10		
18	12	greater than 10		
19		2.5	--	4



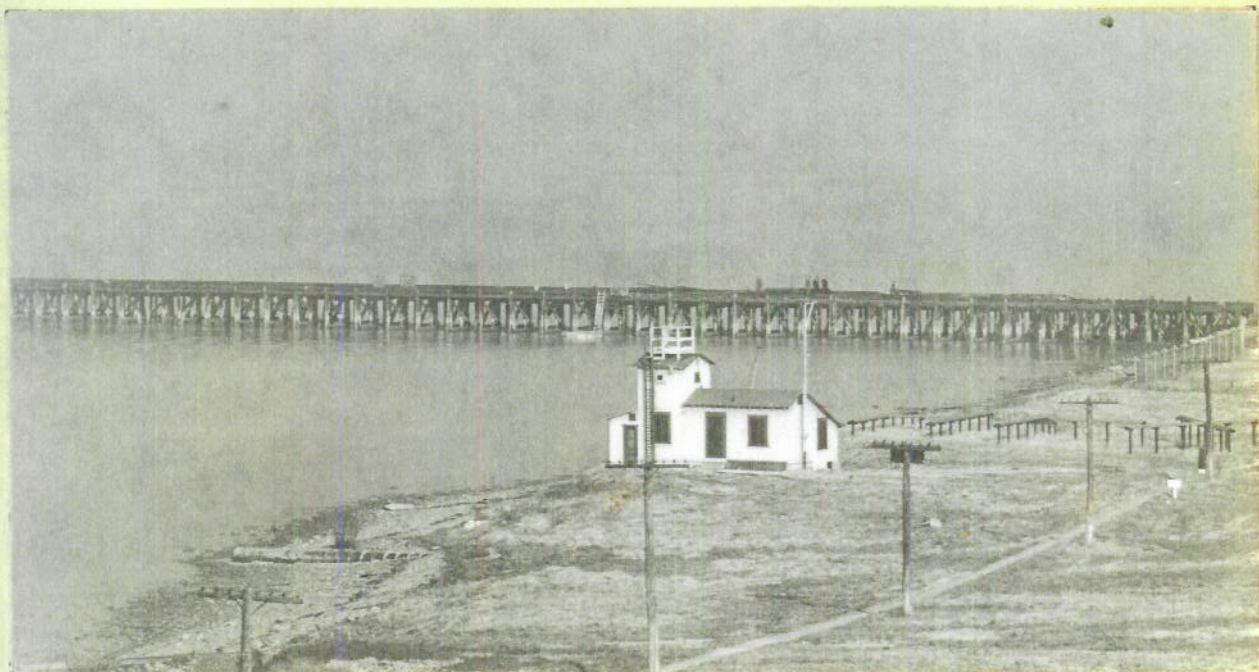
Distances of objects to north
in nautical miles.



Distances of objects to south in
nautical miles.

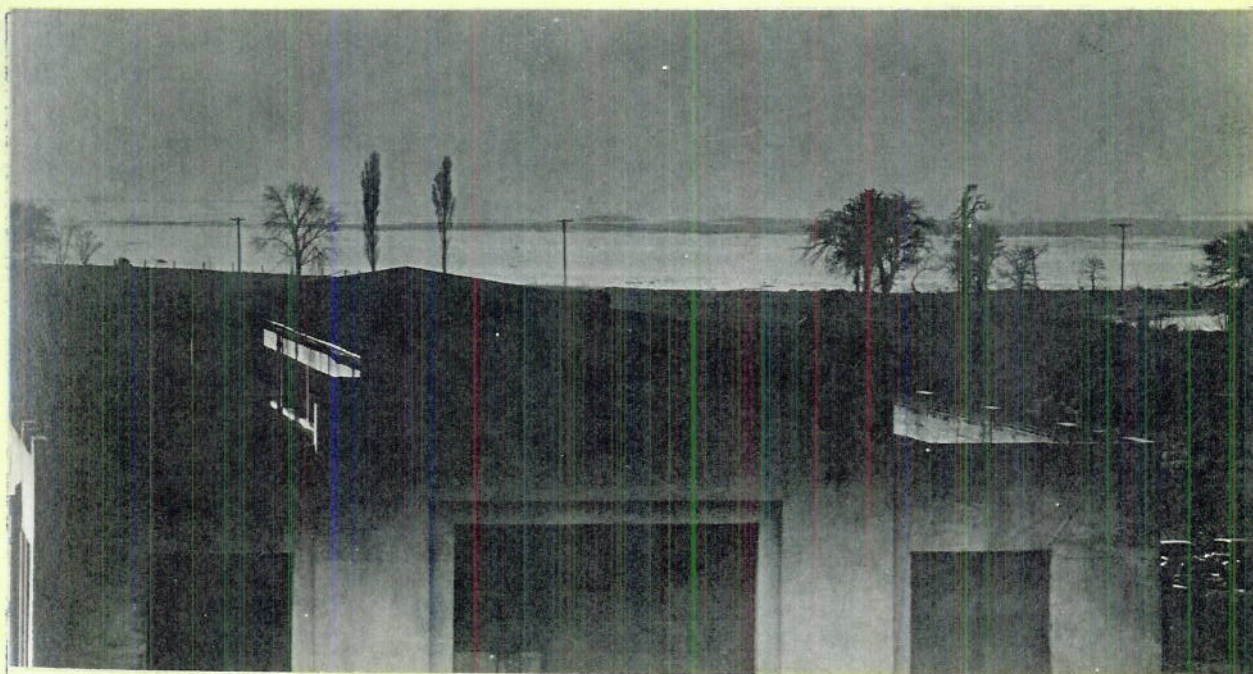


R



P

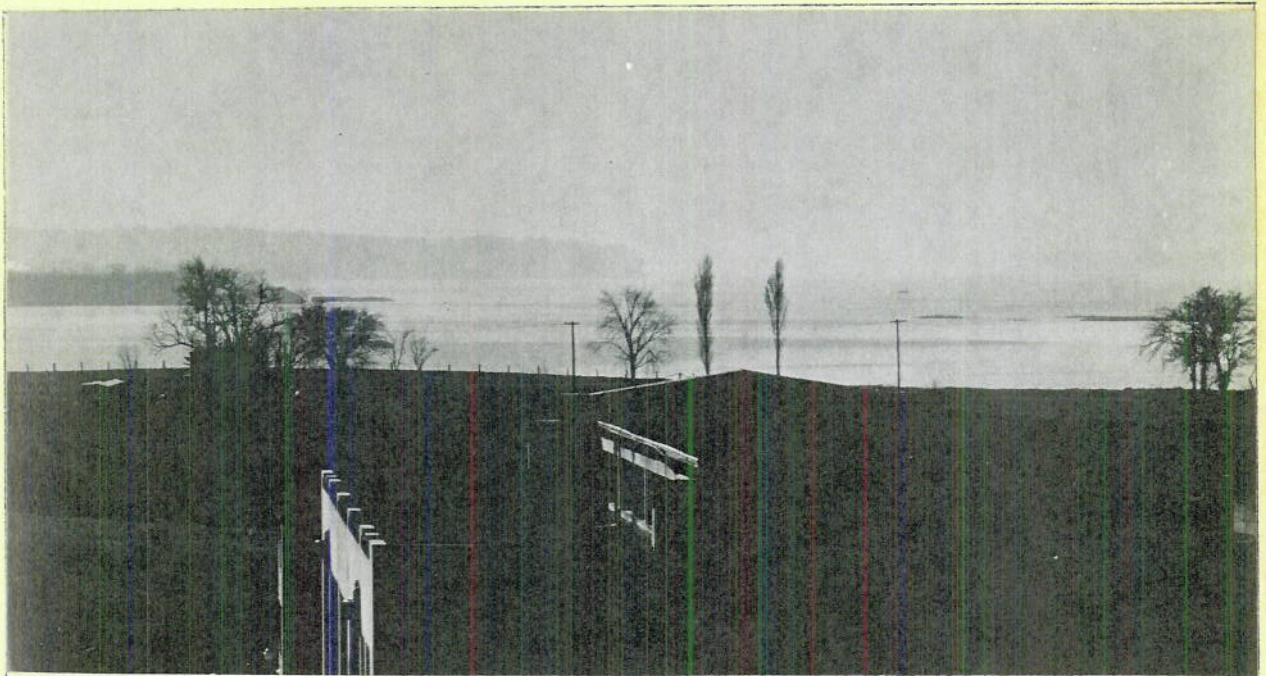
Visibility 2 miles. Thin fog.
November 27, 1933. 10:00 a.m.
Altitude of sun, 23° .
Sun bearing, 150° .



Visibility 2 miles. Thin fog.
November 27, 1933. 10:00 a.m.
Altitude of sun, 23° .
Sun bearing, 30° .



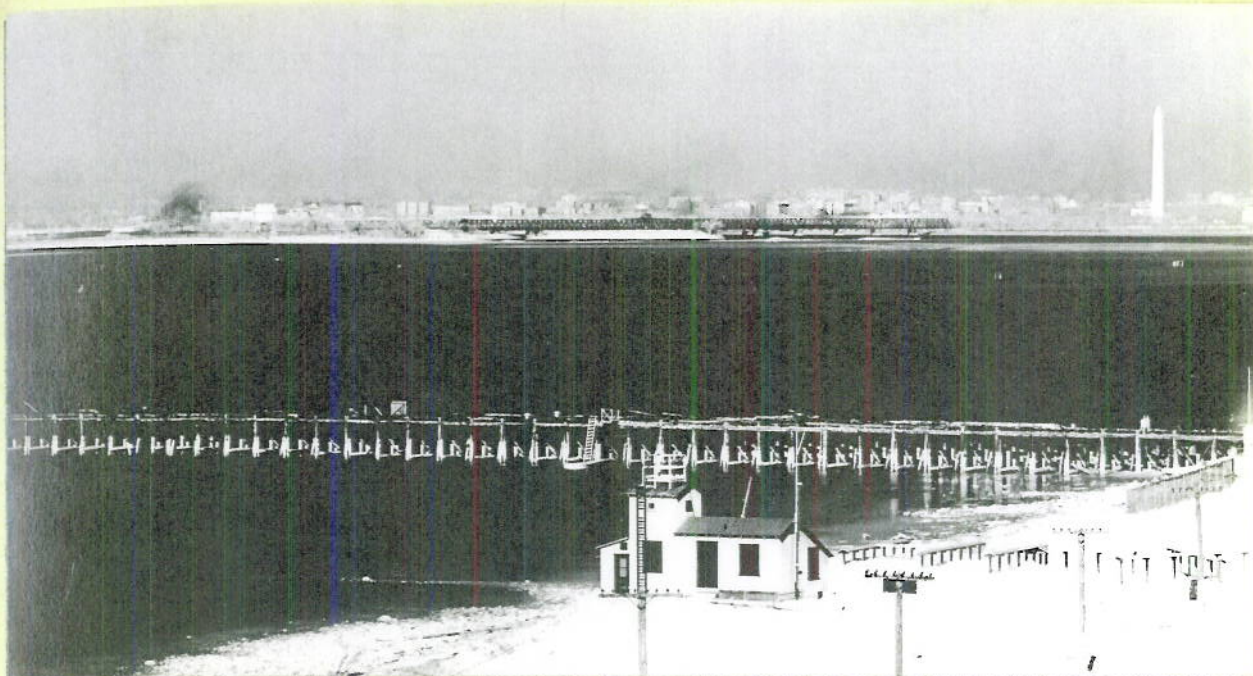
R



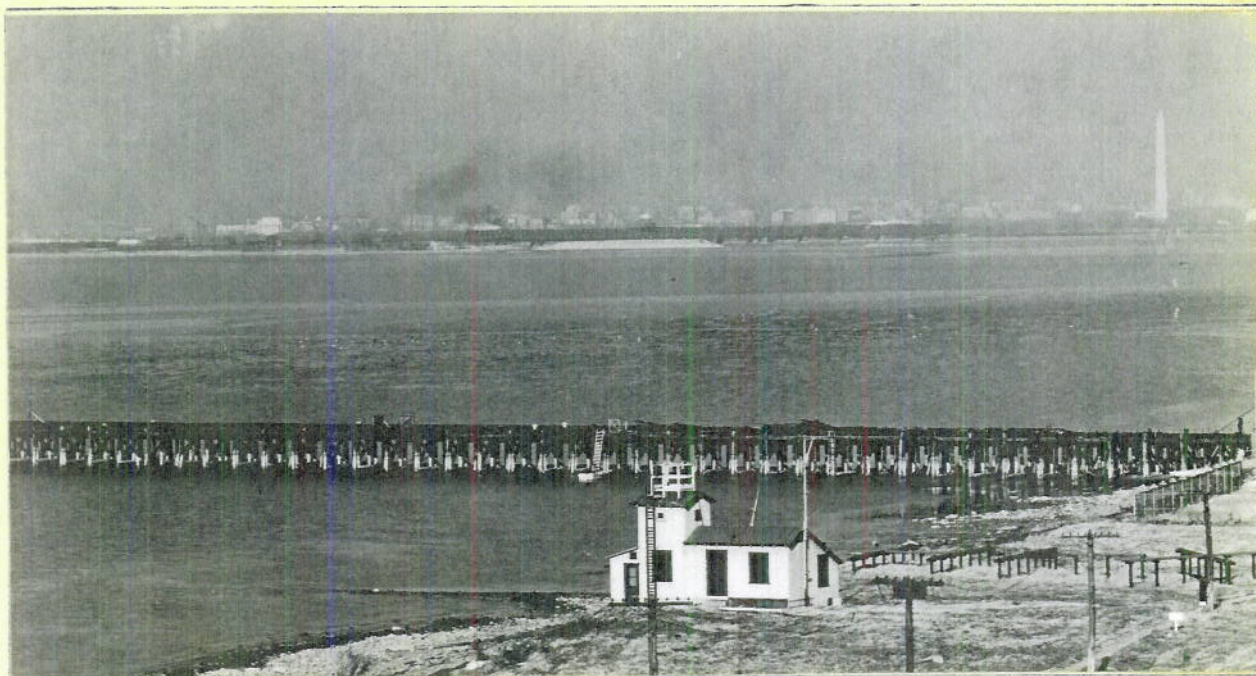
P

Visibility 5 miles. Thickish haze.
December 8, 1933. 10:30 a.m.
Altitude of sun, 24° .
Sun bearing, 35° .

PLATE 6

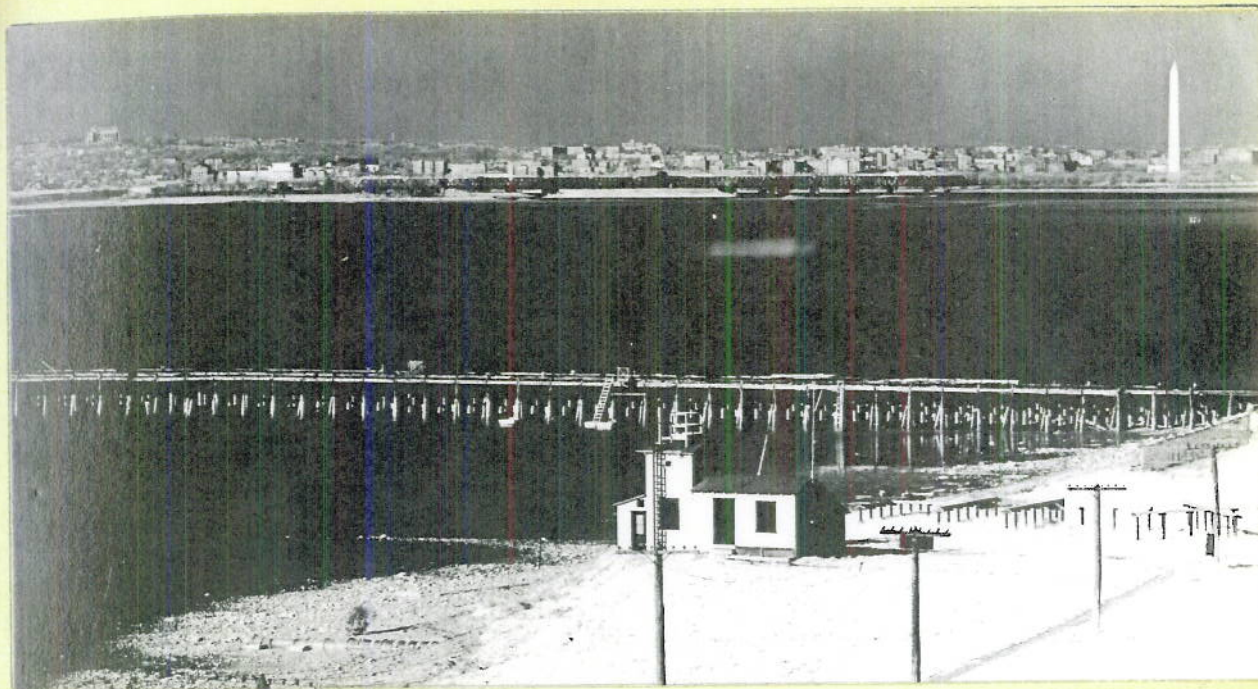


R

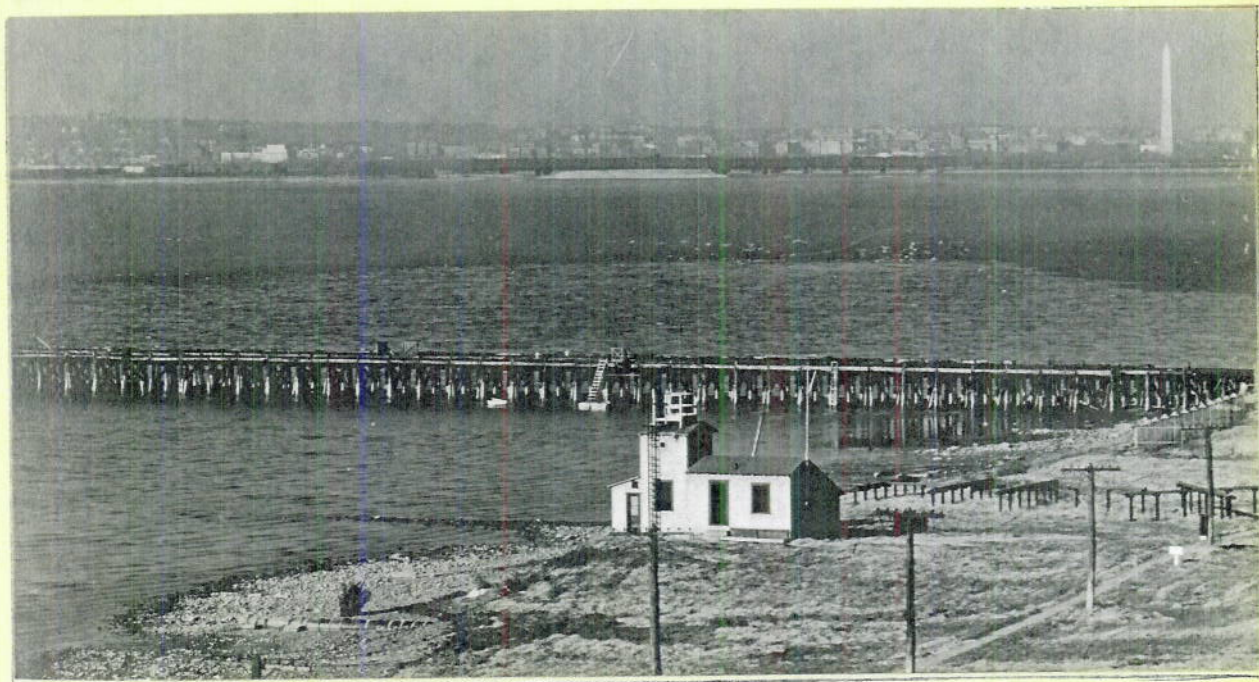


P

Visibility 6 miles. Moderate haze.
November 26, 1933. 11:30 a.m.
Altitude of sun, 26° .
Sun bearing, 170° .

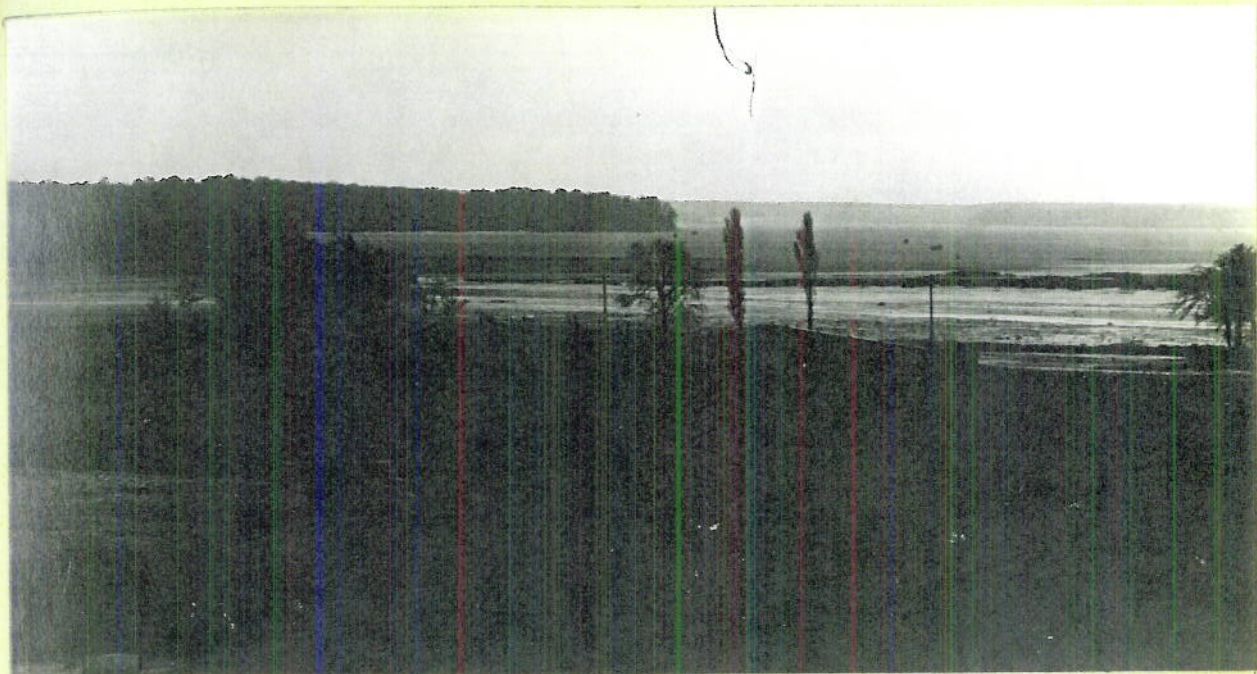


R



P

Visibility 15 miles. Clear.
December 1, 1934. 1:40 p.m.
Altitude of sun, 25° .
Sun bearing, 160° .



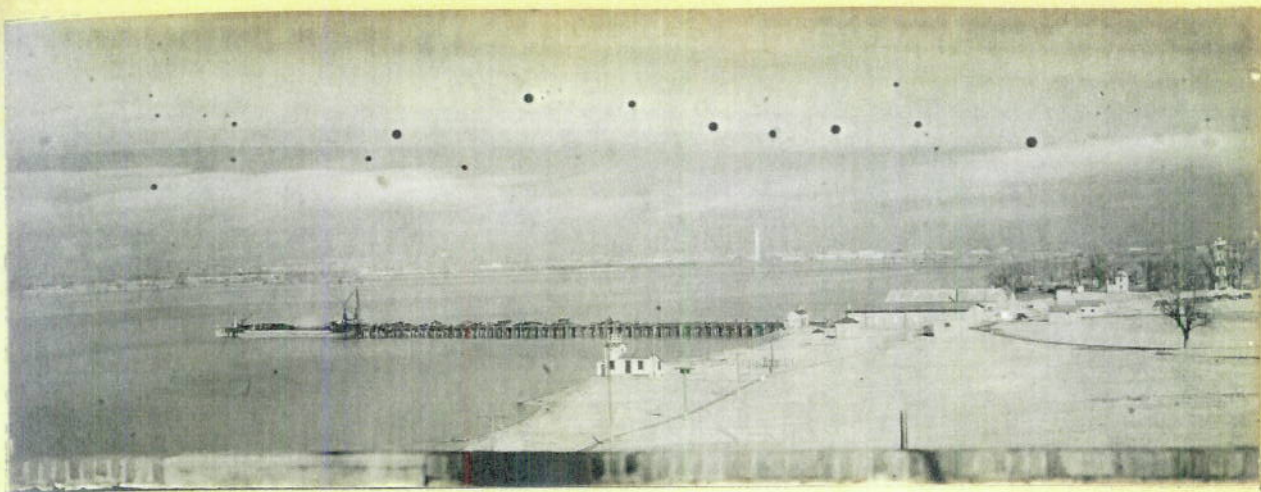
R



P

Visibility 15 miles. Clear.
December 1, 1934. 1:40 p.m.
Altitude of sun, 25° .
Sun bearing, 20° .

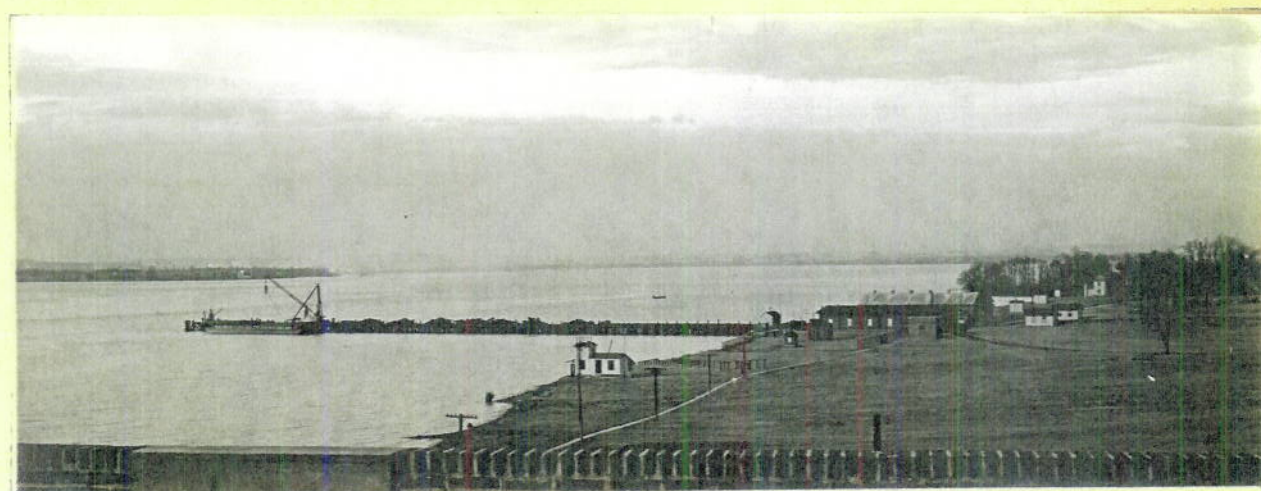
PLATE 10



Q



R



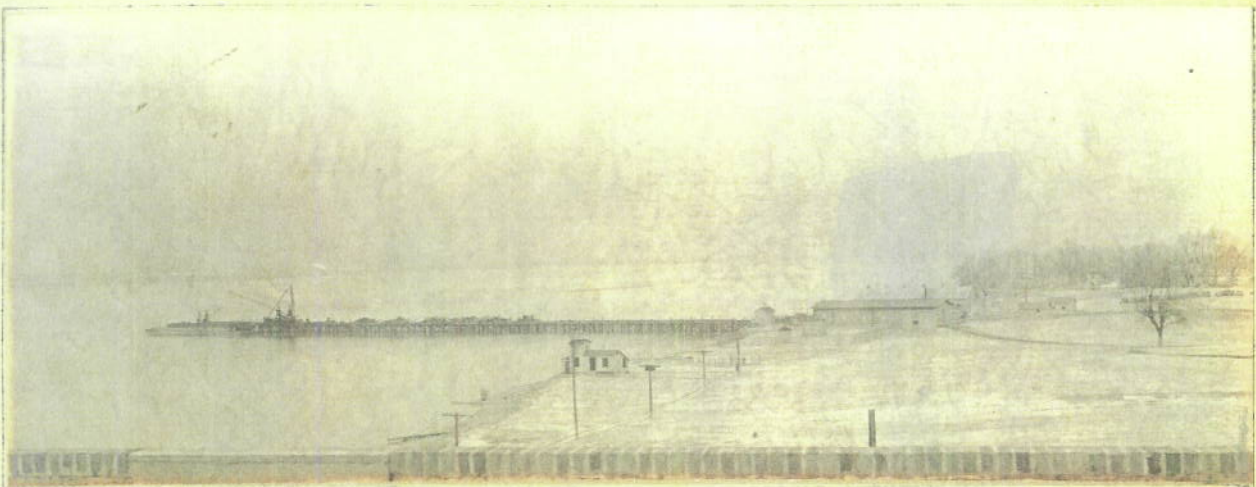
P

Visibility 3 miles. Haze.
January 9, 1934. 10:30 a.m.
Altitude of sun, 27° .
Sun bearing, 170° .

PLATE 11



Q

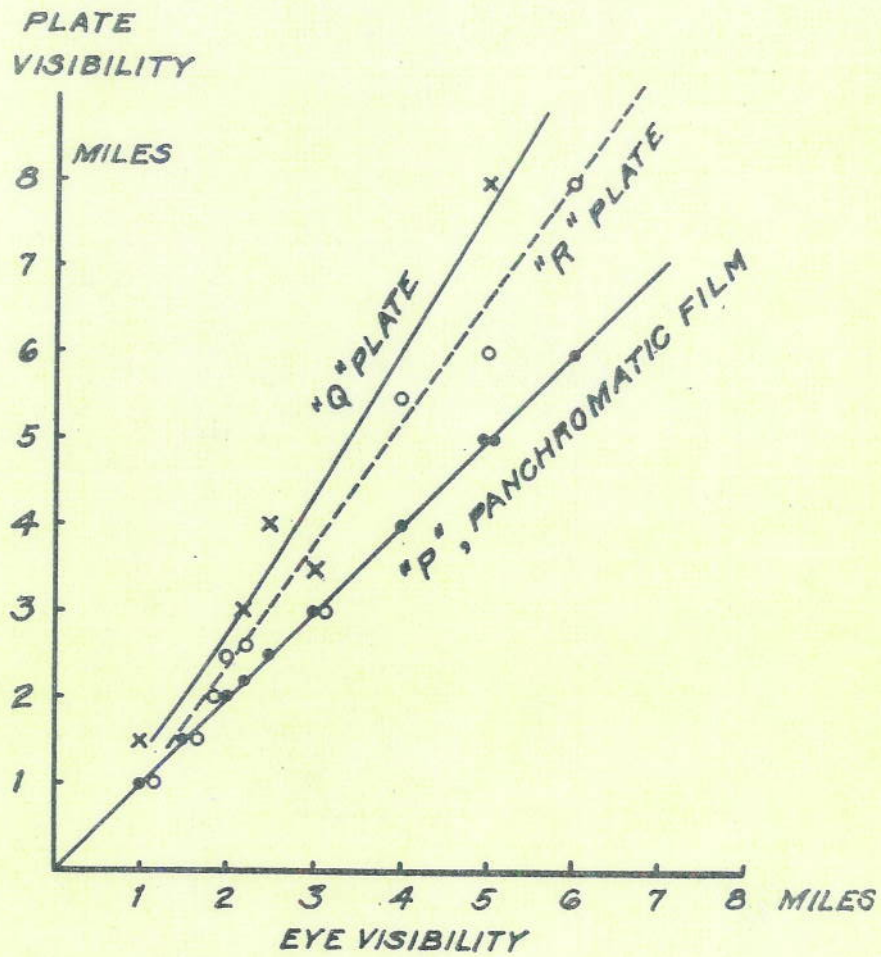


R



P

Visibility 9 miles. Slight haze.
Jan. 9, 1934 10:00 a.m.
Altitude of sun, 26° .
Sun bearing, 160° .



DOTS, CIRCLES AND CROSSES REFER TO
P, R AND Q PLATES, RESPECTIVELY.

PLATE 13